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Neutron-Rich In and Cd Isotopes Close to the Doubly-Magic ^{132}Sn

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Abstract. Microsecond isomers in the In and Cd isotopes, in the mass range $A = 123$ to 130 , were investigated at the ILL reactor, Grenoble, using the LOHENGRIN mass spectrometer, through thermal-neutron induced fission reactions of Pu targets. The level schemes of the odd-mass $^{123-129}\text{In}$ are reported. A shell-model study of the heaviest In and Cd nuclei was performed using a realistic interaction derived from the CD-Bonn nucleon-nucleon potential.

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Experimental progress is currently being made in the region around doubly-magic ^{132}Sn . However, nuclear structure information is more complete for nuclei above the $Z=50$ shell-closure [1] such as Sb and Te isotopes than for the In and Cd isotopes, which are much more difficult to produce. In the present work we searched for and studied the decay of μs isomers in the neutron-rich mass $A = 123$ to 130 nuclei with the LOHENGRIN spectrometer at the ILL reactor in Grenoble. The aim was to complete the previous data on the heavy Cd and In isotopes.

The low-spin levels up to $13/2$ in $^{123-127}\text{In}$ were previously investigated from the β -decay of Cd isotopes [2,3], and, very recently, high-spin ms isomers in $^{125-129}\text{In}$ were discovered [4,5]. Krauttsch *et al* [6], have also obtained some spectroscopic information on the $^{126-128}\text{Cd}$ isotopes. Preliminary reports were presented by Hellström *et al* [7,8] on the search for μs isomers in the heavy Cd and In isotopes at the FRS spectrometer at GSI, but no level schemes were proposed.

Our new results on odd-In isotopes have been published recently [9,10]. In ^{127}In we have observed a $9(2)$ μs isomer which decays by a cascade consisting of a strongly-converted E2 transition of 47 keV, and two γ -rays of 221 and 233 keV in coincidence one with the other (fig. 1,2). The two γ -rays were the same as those first observed by Hellström *et al* [7,8], and the reported value of the half-life $13(2)$ μs is in rough agreement with that found in this work. The coincidence spectra presented on fig. 1 was obtained with the two new clover detectors and the new chamber. It shows the improvement of the γ -efficiency of our setup.

The Si(Li) spectrum obtained in coincidence with any of these two lines shows the characteristic indium X-rays, and the K and L conversion electrons of the isomeric transition. The multipolarity of the transition is E2, and $B(E2)=0.3$ W.u. was deduced.

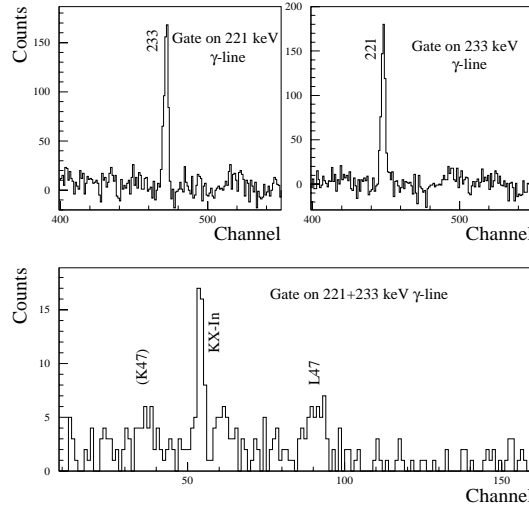


FIGURE 1. Coincidence spectra gated on the γ -ray of 233 or 221 keV and Si(Li) spectrum obtained in coincidence with the γ -rays of 221 and 233 keV.

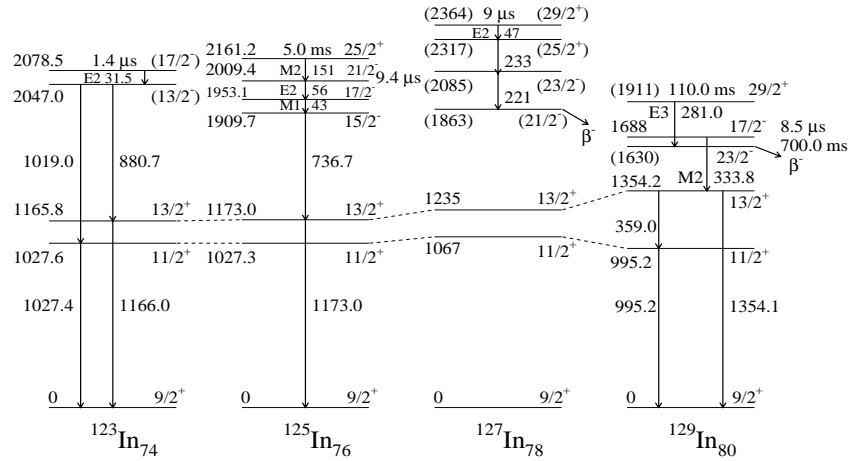


FIGURE 2. Level schemes of $^{123,125,127,129}\text{In}$. The level energies in parenthesis are deduced from β -spectra [5] have large uncertainties.

The level schemes of $^{123-129}\text{In}$ shown in fig.2 are the result of the synthesis of different works: the ms isomer experiments performed at the OSIRIS mass separator [4,5], and the μs isomer experiments performed with the FRS at GSI [7,8] and the LOHENGRIN spectrometer[1,9,10]. All the reported levels are in the vicinity of the yrast line, therefore the low-spin levels fed in previous works by β -decay experiments are not shown in fig. 2.

The heavy In and Cd nuclei, with neutron and proton holes inside the ^{132}Sn core, are characterized by the presence of two high-spin states, $\pi g_{9/2}^{-1}$ and $\nu h_{11/2}^{-1}$ at low

excitation energy. The very strong p - n interaction in the $(\pi g_{9/2}^{-1} \nu h_{11/2}^{-1})$ configuration is expected to produce very perturbed yrast line and give rise to long-lived high spin isomers.

We have performed calculations to test the ability of the shell model to describe the heavy Cd and In isotopes, with proton and neutron holes outside the ^{132}Sn core. In this work, a realistic effective interaction derived from the CD-Bonn nucleon-nucleon potential [11] is used. Similar calculations were performed in Ref. [12] for nuclei with proton particles and neutron holes around ^{132}Sn , and in Ref. [9] for ^{129}In . In both cases good agreement with the experimental data was found

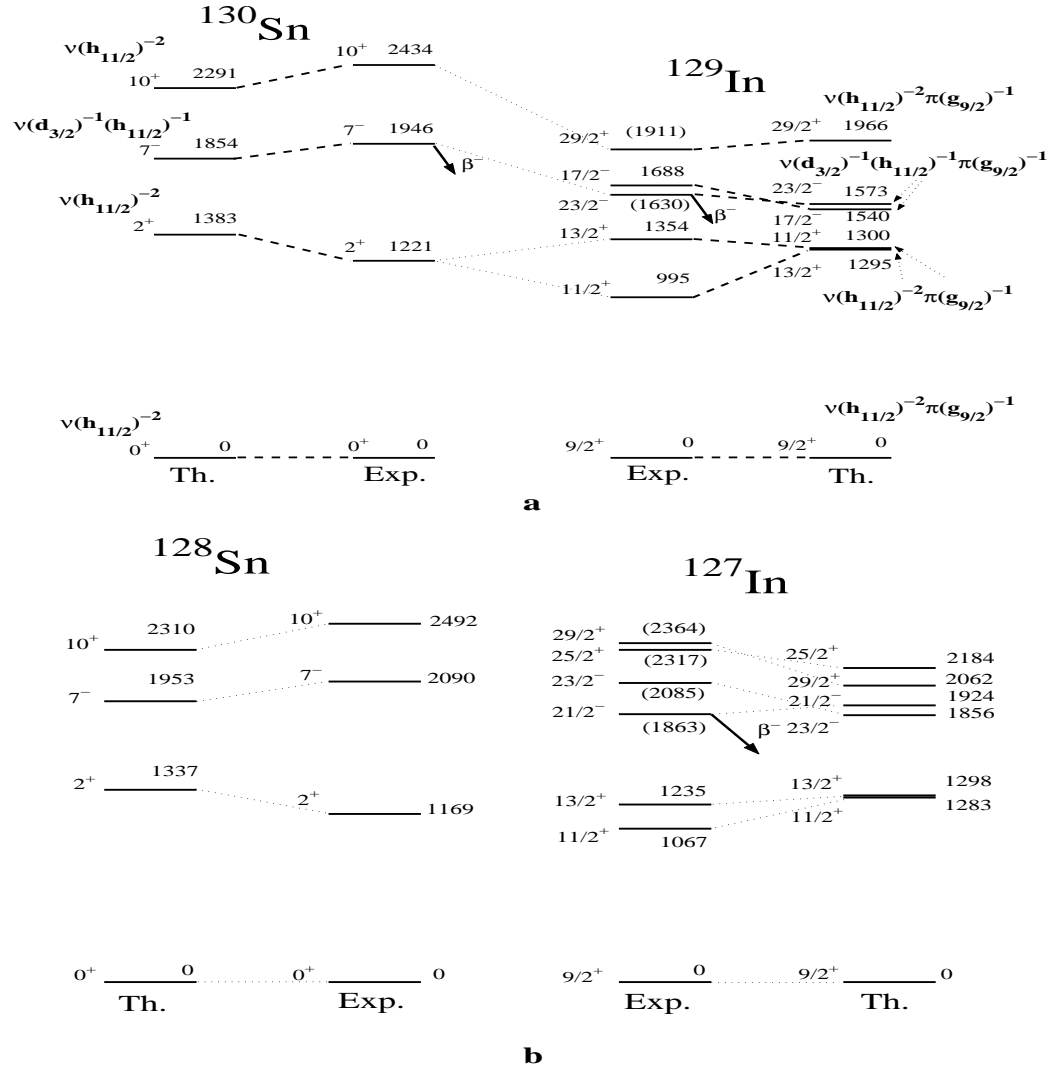


FIGURE 3. Experimental and calculated energies for ^{129}In and ^{130}Sn (a), and for ^{127}In and ^{128}Sn (b).

In Fig. 3a experimental levels of ^{129}In and ^{130}Sn are shown together with the calculated ones. For ^{129}In all the experimental levels, except the $1/2^-$ at 369 keV, are reported, while only some selected yrast level of ^{130}Sn are shown. The dominant configurations of all these levels are also indicated. The excitation energies of ^{130}Sn are rather well reproduced by the shell-model calculations. However, it is interesting to note that the first 2^+ state is overestimated by the calculation by 162 keV. This is a common feature for this state in this region and it is probably an effect of the

truncation of space. The experimental levels of ^{129}In are expected to result from the coupling of a $\pi g_{9/2}^{-1}$ hole with the reported two neutron hole states of ^{130}Sn . The comparison of the experimental levels in Fig. 3b shows that the $29/2^+$ and $23/2^-$ in ^{127}In are closer to the 10^+ and 7^- in ^{128}Sn respectively, than in Fig. 3a. This effect could be explained by a decrease of p - n interaction from ^{129}In to ^{127}In . Another feature, possibly related to the effects of the p - n interaction is the inversion of the $29/2^+$ and $25/2^+$ and $23/2^-$ and $21/2^-$ levels, respectively, in the calculated spectrum of ^{127}In . In the vicinity of the two closed shells of ^{132}Sn the μs isomers are very abundant and disappear rapidly far from them [1]. However, below $Z=50$ they disappear suddenly for the Cd isotopes, no isomers having been identified up to now in the even-mass ones. The calculations for $^{126,128}\text{Cd}$ predict short half-lives (~ 10 ns) for the 8^+ states, which could explain why they have not been observed in the present work. In ^{130}Cd no excited levels are experimentally known up to now. The shell model calculations predict an isomer 8^+ of $0.6 \mu\text{s}$, very close to the LOHENGRIN detection limit. The low yield estimate for this element make a measurement very difficult.

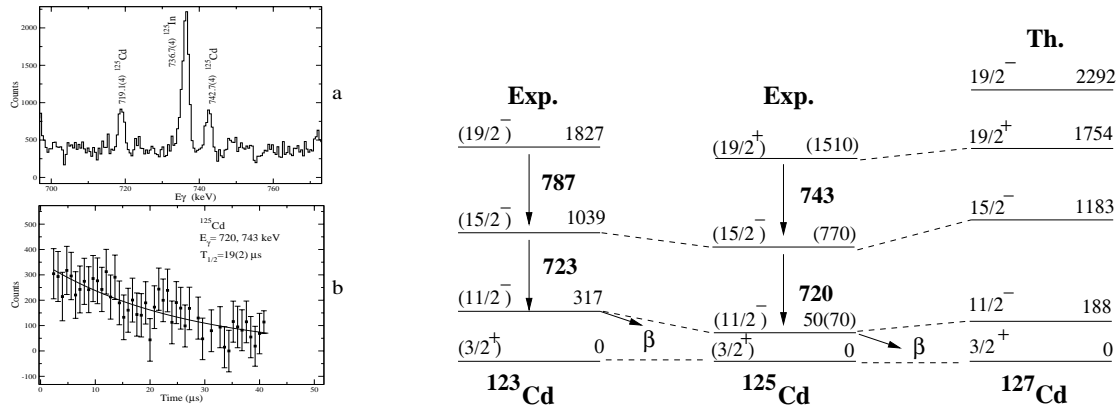


FIGURE 4. γ -spectrum obtained in delayed coincidence with mass $A=125$ (a). Time spectrum of ^{125}Cd (b). Experimental levels of ^{125}Cd in comparison with ^{123}Cd and a theoretical calculation of ^{127}Cd .

In the odd-nuclei, only the isomer of ^{125}Cd , which decays by two γ -lines of the same intensity, as seen in Fig. 4, is known. Its half-life is $19(2) \mu\text{s}$, in rough agreement with the value reported previously [7,8]. A tentative level scheme is proposed by analogy with its neighbour ^{123}Cd and a shell model calculation on ^{127}Cd .

REFERENCES

1. Pinston, J.A and Genevey, J., *J. Phys. G* **30**, R57 (2004)
2. Hoff, P., et al., *Nucl. Phys. A* **459**, 35 (1986).
3. Huck, H., et al., *Phys. Rev. C* **39**, 997 (1989).
4. Fogelberg, B., et al., *Proc. 2nd Intern. Workshop on Fission and Fission-Product Spectroscopy (Seyssins, France)* (AIP Conf. Proc 447) Ed. by G. Fioni, H. Faust, S. Oberstedt, F. Hamsch, p. 191
5. Gausemel, H., et al., *Phys. Rev. C* **69**, 054307 (2004).
6. Krauszsch, T., et al., *Eur. Phys. J. A* **9**, 201 (2000).
7. Hellström, M., et al., *Proc. 3rd Conf. on Fission and Properties of Neutron-Rich Nuclei (Sanibel Island, FL)* 2002, Ed. by J. Hamilton, A. Ramayya, H. Carter (Singapore: World Scientific), p.22.
8. Hellström, M., et al., *Proc. of Intern. Workshop XXXI on Gross Properties of Nuclei and Nuclear Excitations (Hirschegg, Austria)* Ed. by H. Feldmeier, GSI 2003, p.72.
9. Genevey, J., et al., *Phys. Rev. C* **67**, 054312 (2003).
10. Scherillo, A., et al., *Phys. Rev. C* **70**, 054318 (2004), and PhD Thesis, Cologne, Germany 2005.
11. Machleidt, R., et al., *Phys. Rev. C* **63**, 024001 (2001)
12. Corragio, L., et al., *Phys. Rev. C* **66**, 064311 (2002).

